which means that the received signal amplitude A_R must be proportional to the transmitter's amplitude A_T and inversely related to distance from the transmitter.

$$A_R = \frac{kA_T}{d}$$

(6.17)

for some value of the constant ***k***. Thus, the further from the transmitter the receiver is located, the weaker the received signal. Whereas the attenuation found in wireline channels can be controlled by physical parameters and choice of transmission frequency, the inverse-distance attenuation found in wireless channels persists across all frequencies.

Exercise 6.4.1

Why don't signals attenuate according to the inverse-square law in a conductor? What is the difference between the wireline and wireless cases?

The speed of propagation is governed by the dielectric constant μ_0 and magnetic permeability E_0 of free space.

$$\begin{aligned} c &= \frac{1}{\sqrt{\mu_0 \epsilon_0}} \\ &= 3 \times 10^8 m/s \end{aligned}$$

(6.18)

Known familiarly as the speed of light, it sets an upper limit on how fast signals can propagate from one place to another. Because signals travel at a finite speed, a receiver senses a transmitted signal only after a time delay inversely related to the propagation speed:

$$\Delta(t) = \frac{d}{c}$$

(6.19)

At the speed of light, a signal travels across the United States in 16 ms, a reasonably small time delay. If a lossless (zero space constant) coaxial cable connected the East and West coasts, this delay would be two to three times longer because of the slower propagation speed.

6.5 Line-of-Sight Transmission

Long-distance transmission over either kind of channel encounters attenuation problems. Losses in wireline channels are explored in the Circuit Models module (Wireline Channels (Page 263)), where repeaters can extend the distance between transmitter and receiver beyond what passive losses the wireline channel imposes. In wireless channels, not only does radiation loss occur, but also one antenna may not "see" another because of the earth's curvature.